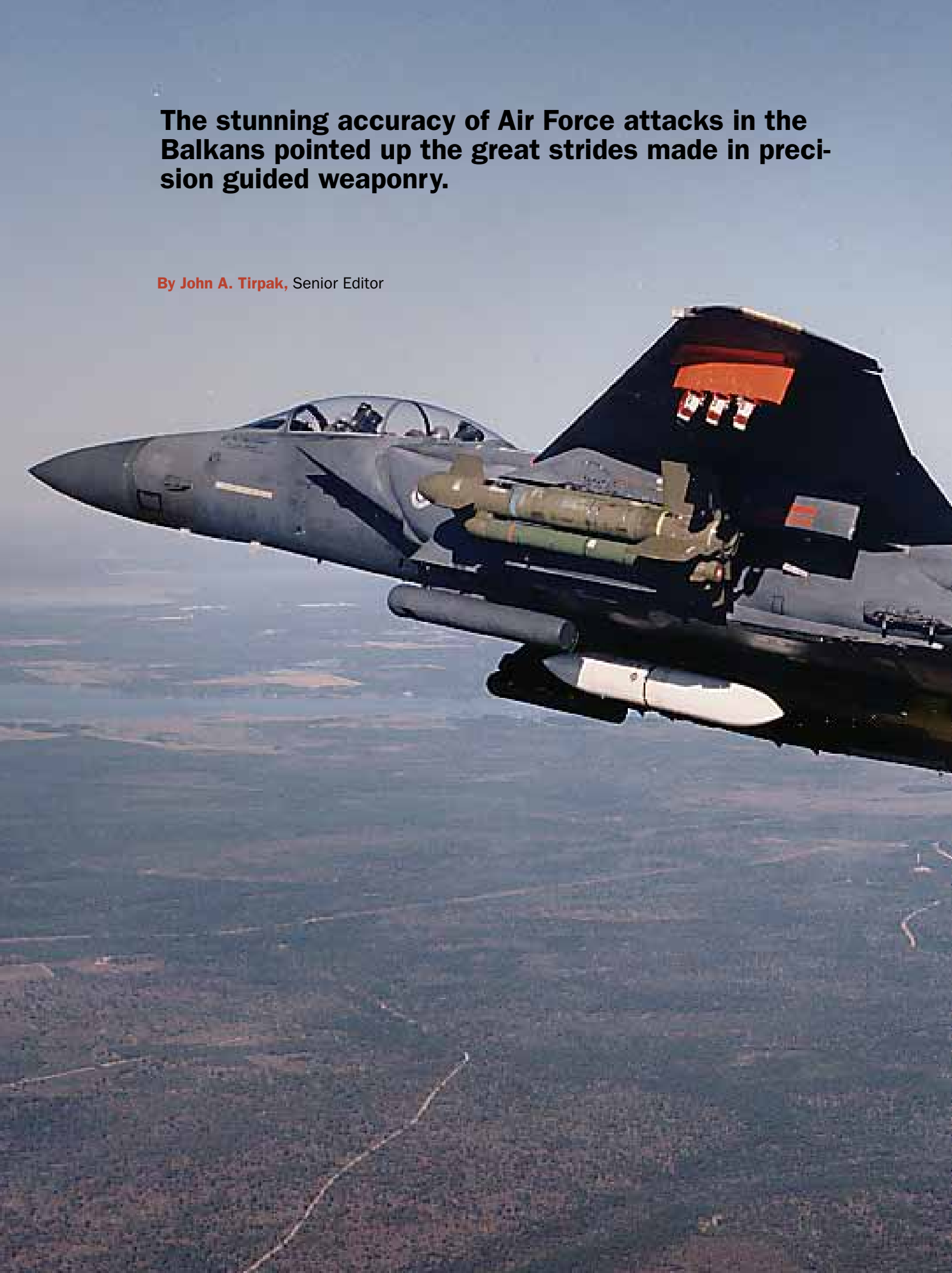
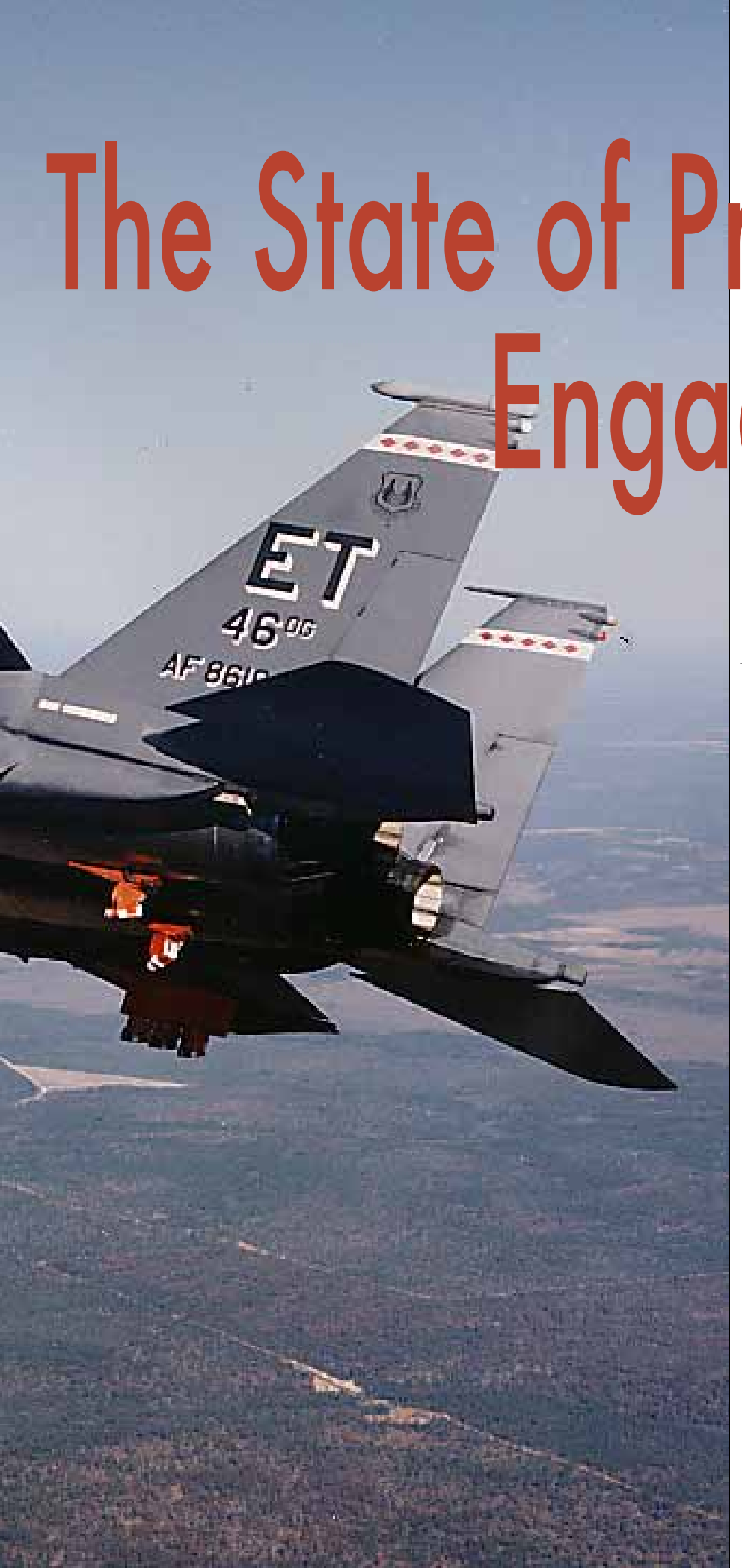
The stunning accuracy of Air Force attacks in the Balkans pointed up the great strides made in precision guided weaponry.

By John A. Tirpak, Senior Editor



The State of Precision Engagement



OPERATION Allied Force demonstrated that true precision air attack—once a far-off goal but now taken for granted—has become an indispensable capability. It proved to be vital not just for the prosecution of the Balkan military effort but also as a means of holding together the Western coalition by minimizing civilian casualties and damage.

Air Force officials long have recognized the pivotal role played by precision guided weapons. The service now is mapping a future inventory of systems that will be even more precise and adaptive, yet lighter and less expensive, than the current generation of systems just now being deployed.

Precision Guided Munitions made Allied Force possible. The operation likely would not even have been attempted had NATO leaders not been convinced—by experience in Deliberate Force in 1995 and Desert Storm in 1991—that the destructive power of coalition airstrikes could be almost entirely confined to military targets.

The Supreme Allied Commander Europe, Army Gen. Wesley K. Clark, told the Senate Armed Services Committee last October that NATO commanders knew going into the Yugoslavian operation that "we weren't

USAF photo by SSgt. Paul Caron

Use of precision weapons has expanded greatly since the 1991 Gulf War. Nearly all munitions used in NATO's Operation Deliberate Force in 1995 were PGMs. Here, an F-15E is loaded with a Laser-Guided Bomb at Aviano AB, Italy.

going to be allowed to use decisive force" to compel Slobodan Milosevic to comply with NATO demands. By that, he meant that a large-scale ground operation, massive bombing, or other brute-force effort was out of the question.

Instead, NATO planners would have to settle—initially, at least—for what Sen. Carl Levin (D–Mich.) dubbed "maximum achievable force" in a phased air operation. That, Clark said, meant attacking an "irreducible minimum" of targets, those posing an immediate threat to allied airplanes. As the conflict progressed, the target list expanded, but NATO leaders wanted to "have their hand on the trigger, so to speak," Clark said. They were desperate to avoid civilian casualties and limit the damage to the minimum necessary to force Milosevic to capitulate.

Air Force Lt. Gen. Michael C. Short, the joint forces air component commander, said he was urged to do his utmost to both avoid civilian casualties on the ground and NATO losses in the air. This goal prompted the creation of strict protocols with regard to target selection and identification and to the weapons chosen to attack each one.

Twenty Out of 23,000

In practice, only 20 of the approximately 23,000 munitions expended by NATO in the 1999 Balkan air operation caused collateral damage or civilian casualties. Some others were deliberately steered off course to avoid harming civilians who had not been seen in the target area until the last moment.

In a joint statement to Congress last fall, Clark, Adm. James O. Ellis Jr., commander in chief of NATO's Allied Forces Southern Europe, and Short said, "NATO did everything possible, everything feasible, to focus on the enemy and keep harm away from innocent civilians."

The American PGMs, they said, "proved very effective and demonstrated immense potential by allowing highly accurate strikes while minimizing collateral damage and civilian casualties."

NATO nations abhorred all civilian deaths, and their militaries went to extraordinary lengths to avoid them. Bombing accuracy, coupled with zero friendly casualties due to enemy fire, was equally unprecedented. The achievement was so stark it left many commanders worried that they had set a standard that never again would be met.

PGMs in Allied Force represented just 35 percent of the ground-attack weapons used but accounted for 74 percent of the targets destroyed. The percentage of PGMs as a fraction of weapons used was much higher in the early weeks of the war, when they were used almost exclusively. Later, as big bombers swept in with large numbers of unguided munitions, the ratio shifted.

Allied Force represented "the most precise bombing campaign in history," Army Gen. Henry H. Shelton, Joint Chiefs Chairman, told Congress last fall. This was achieved due in large part to the strides in precision attack made by the Air Force in the 1990s and demonstrated "the wisdom of decisions taken after the 1991 Gulf War," Defense Secretary William S. Cohen and Shelton said in a joint written statement to Congress in October.

Before Desert Storm ended, the Air Force had recognized that, despite its tremendous success with PGMs, there was plenty of room for improvement. Nonstealthy aircraft, if they were to survive, had to have the means to attack targets from outside the effective range of anti-aircraft artillery and surface-to-air missiles. All strike aircraft—stealthy and nonstealthy—needed a capability to carry out precision strikes at night and in bad weather, the latter of which sidelined strike activity for days at a time during Allied Force.

Some steps in these directions were already under way even before the Gulf War began, but the Air Force intensified its campaign in the aftermath. The service undertook three principal efforts: equipping nearly all fighters with the capability to use Laser-Guided Bombs; greater dissemination of night vision gear; and introducing a new class of low-cost, satellite-guided weapons.

Night Into Day

The LGB capability—as well as a large degree of night capability—was acquired when the Air Force equipped much of its F-16 force with the system called LANTIRN, or Low-Altitude Navigation and Targeting Infrared for Night. This podded system gives the pilot a cockpit display of blacked-out terrain almost as if it were daylight. Zoom features allow the pilot to get a close-up view of a distant object and put a weapon's crosshairs on it.

Other aircraft, notably the A-10, got special lighting and night vision goggles, which proved to be a less costly (but also less effective) means of obtaining night capability.

Laser-Guided Bombs, viewed by the public as the hallmark of Desert Storm, represented only 4.3 percent of the munitions used in that conflict (all PGMs accounted for 9

percent). The LGBs accounted for 75 percent of the damage inflicted on Iraqi forces and infrastructure. However, they could only be used by certain specially equipped aircraft and would not work if forced to drop through heavy overcast or smoke. An effort was begun to remove weather as a hindrance to precision attack as well as a refuge for the enemy.

The Air Force, well prior to the Gulf War, secretly had converted a number of AGM-86B Air Launched Cruise Missiles to a conventional version, the AGM-86C, employing Global Positioning System cuing. The weapon would allow the Air Force to strike at highly defended targets hundreds of miles away without putting aircrews within range of enemy defenses.

As with any GPS receiver, the unit interrogates GPS satellites as to the missile's location, triangulating response times to establish a position both in space and time. Thirty-five Conventional Air Launched Cruise Missiles were used in Desert Storm's opening volley, though their existence and employment was not revealed until a year later.

The CALCM represents "the outer layer of standoff attack," an Air Staff weapons expert observed. The operational concept of precision engagement calls for using small numbers of expensive, long-standoff-range weapons first, gradually moving to larger numbers of shorter-range, less-expensive weapons as enemy air defenses are beaten down.

Only B-52s can carry the AGM-86C, which can have the GPS coordinates of their targets programmed before they are loaded or updated en route to the release point.

The Rush to Replenish

CALCMs were employed with great effect in Allied Force—principally against infrastructure targets like power plants and command-and-control nodes—but at such a rapid pace that the Air Force had to negotiate a new contract with Boeing to convert even more of the AGM-86Bs to CALCM configuration.

Under a $122 million contract, Boeing will convert 322 more missiles. The last 50 will be a special type, designated AGM-86D, capable of penetrating a hardened, deeply buried target.

Some CALCMs will have a means of terminal guidance to give them pinpoint accuracy, but specifics on the guidance package are classified.

Only a specific number of ALCMs can be converted to CALCMs, and no more. Thus, the Air Force is leading an effort to develop a stealthy successor, which the Navy will also use to succeed its Tomahawk Land Attack Missile. The new weapon is the AGM-158 Joint Air-to-Surface Standoff Missile.

The JASSM, equipped with up to a 2,000-pound-class warhead, will have a range of hundreds of miles and all-weather, pinpoint accuracy, obtained through a combination of GPS cuing, Inertial Navigation System, and terminal seeker. The JASSM will also have capability for penetrating hardened targets.

"The operational concept for JASSM is very similar to that for CALCM," an Air Staff weapons expert reported.

However, there is a big difference—cost. Big current-generation cruise missiles like ALCM and TLAM cost more than $1 million apiece. JASSM is slated to cost about $400,000 apiece over a run of 2,400 units, thanks to streamlined contracting practices put in place over the last six years. Lockheed Martin is building the JASSM.

The next rung on the standoff arc is currently occupied by the Air Force's AGM-130 rocket-assisted glide bomb and AGM-142 Have Nap missile and the Navy's Standoff Land Attack Missile–Extended Range.

The AGM-130 is a 2,000-pound-class bomb that can be carried only by the F-15E. It has a TV or infrared seeker in the nose and a data link to a launching aircraft, allowing the F-15E backseater to "fly" the bomb to its target by means of a miniature TV screen in the cockpit and a hand-controller. To prevent the missile from being jammed or rerouted, each AGM-130 is controlled by a specifically tuned data-link pod mounted under the F-15E.

The rocket motor allows a wide variety of approaches to the target; for example, the bomb can glide low, under the overcast, while the controlling airplane remains above. More practically, the F-15E can also release the bomb and stay out of the reach of surface defenses while the missile goes the final distance.

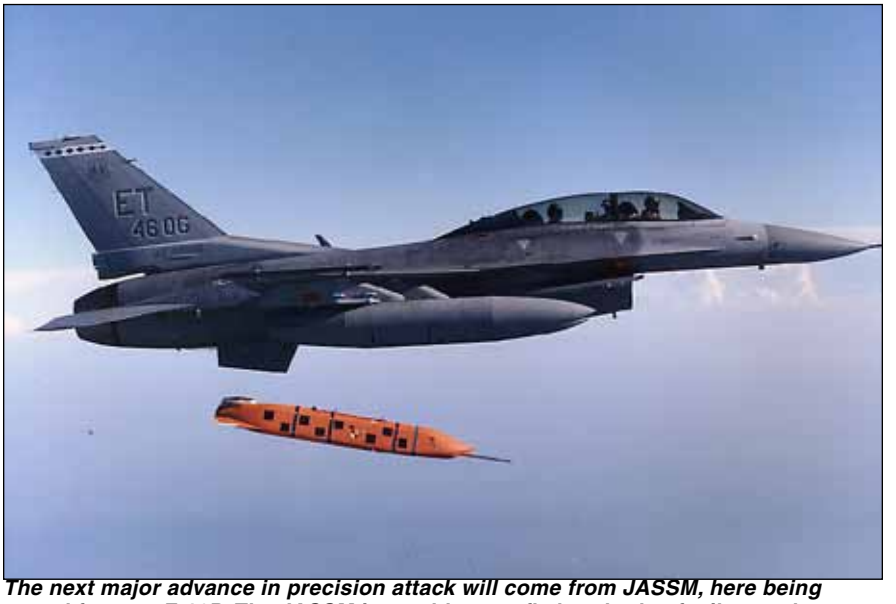
All AGM-130s now have GPS capability. This ensures at least a near-precision attack if the data link fails or in case the guiding crew member loses his visual references.

Constricted View

The image in the cockpit received from the missile nose "is like looking through a straw," the Air Staff weapons expert said. Having the GPS capability is an extra guarantee that the weapon will hit close to its aim point.

The SLAM–ER and Have Nap work in ways similar to the AGM-130. All are able to make a precision attack on

USAF photo by TSgt. Mike Ammons



The next major advance in precision attack will come from JASSM, here being tested from an F-16D. The JASSM is stealthy, can fly hundreds of miles, and can strike hardened targets with high accuracy.

a target from a distance of at least 20 miles. (Maximum potential range for the Navy missile is 93 miles and the Have Nap, about 50 miles.)

Closer in, 15 miles or so from the target—its range depends on the speed and altitude of the launch platform—strike aircraft will use the new AGM-154 Joint Standoff Weapon.

Led by the Navy, the JSOW program is providing a stealthy glide bomb that uses GPS to find its target. JSOW is now being delivered to the Air Force, which plans to buy 3,000 of the bomblet version that costs about $180,000 apiece, and more than 3,100 of a Sensor Fuzed Weapon variant at $330,000 apiece. The SFW is a smart weapon that fires projectiles down on individual vehicles in an armored column or convoy. The B-2 will be the first Air Force platform to receive JSOW, but the B-1, B-52, F-15E, and F-16 are all slated to use it. (The Navy has already employed its JSOW in combat. An F/A-18 on routine patrol over Iraq fired the first one in January 1999 at an Iraqi air defense site.)

The pilot employing the JSOW need only release the weapon; the GPS coordinates of its target will already have been programmed into the bomb.

Stealth was incorporated in JSOW to ensure surprise of attack, as well as to foil attempts to shoot down the glide bomb on its approach to target.

Another weapon that can be used inside 15 miles is the new GPS version of the GBU-15 glide bomb, the EGBU-15, which is identical to the AGM-130 but lacks the rocket motor for extended range. The EGBU-15 has improved accuracy and all-weather capability.

As USAF fighters get within sight of the target, they can employ Laser-Guided Bombs. The LGB looks for the reflection of laser light being aimed at the target. An onboard laser designator is typically used, but the target can be designated by another aircraft or even a soldier on the ground using a handheld laser. The LGB looks for reflected laser light of the right frequency, then follows it until the bomb hits the target. The pilot will "steer" the laser spot—which appears as a cursor on a cockpit video display—with a joystick toward a vulnerable point on the target—typically, a supporting beam or an unhardened point of entry. The bomb receives these inputs and translates them into movements of the fins on its tail.

Early model GBU-10 and -12 Laser-Guided Bombs use full deflection of their fins when steered toward the target and typically must be used from higher altitudes and closer to the aim point because they rapidly use up their gliding energy. Later versions like the GBU-24 and -27 can make smoother adjustments to their flight path and can be used at lower altitudes. The latter weapon can score a hit within about 10 feet of the target.

USAF photo by SrA. Jeffrey Allen

The massive GBU-28 LGB is a bunker buster, designed to destroy deeply buried and superhardened targets. This monster bomb was used in Desert Storm as well as Allied Force.

The Air Force is putting GPS receivers on all its LGBs to make them capable in all weather and to salvage missions that might have to be scrubbed en route because of smoke or other obscurants over the target area.

The GBU-28 is a special 5,000-pound bomb with a GBU-27 laser seeker. It and the follow-on GBU-37, which is GPS–guided, are intended to be "bunker busters," massive bombs able to destroy deeply buried, hardened targets such as command centers.

The Modern Way to Spot

One Allied Force innovation, barely used before the air campaign ended, was the installation of a laser designator on the Predator Unmanned Aerial Vehicle. This capability will in the future allow low-flying UAVs to precisely pick aim points for LGBs without endangering aircrews.

Heartened by the success of the CALCM in the Gulf War, the Air Force decided to expand on the use of GPS in its next generation of ground-attack munitions.

The Joint Direct Attack Munition was developed as a direct response to the weather frustrations experienced in Desert Storm. The JDAM GBU-31 variant has a 2,000-pound bomb equipped with fins to extend the range at which it can be released and a tailcone that can receive GPS data and translate them into fin movements that steer the bomb to precise coordinates. The JSOW, developed in parallel, uses a similar approach.

Both the JDAM, made by Boeing, and JSOW, built by Raytheon, were on the verge of completing operational tests when Allied Force began. Initial production batches were rushed into operational use. The JDAM, employed exclusively by the B-2, worked brilliantly.

The combination of B-2 and JDAM was "the No. 1 success story" of the allied effort, Short asserted.

The B-2 employed JDAM in a unique way that will not be used by other aircraft when they are cleared to use the weapon. The B-2 can not only program the JDAM with the GPS coordinates it wants to hit, but it can update those coordinates after comparing them with a synthetic aperture radar map the bomber makes of a target area prior to weapons release. By means the Air Force prefers not to discuss, the B-2 mission commander

can actually choose elevation as well as coordinates for the JDAM, effectively permitting him to select aim points on the target. This capability is called the GPS–Aided Targeting System.

Bad Weather Performer

A total of 656 JDAMs were used during Allied Force. Just as the weapon began to stand out as a stellar performer—even during bad weather (there was 50 percent cloud cover more than 70 percent of the time)—in keeping the pressure on Serb leadership, stocks of the weapon began to run low.

"We started out [in Allied Force] with about 300 JDAMs," said Joseph G. Diamond, Air Force program executive officer for weapons, "because the weapon was still technically in its test phase. ... We went back to the contractor and started ramping up production." By January 2000, more than 2,500 JDAMs had been delivered.

JDAM is counted as a near-precision munition, said an Air Staff weapon expert. LGBs, considered precision weapons, have a 10-meter circular error probable, meaning that half of all bombs dropped will fall within 10 meters of the target. JDAM is not quite as precise, but, in real-world experience in Yugoslavia, it proved comparable to LGBs in accuracy. The B-2s in Allied Force put 90 percent of their JDAMs within 12 meters of their targets.

"For weaponeering purposes, we treat JDAM as a precision weapon," the Air Staff expert said.

The JDAM tail kit goes on a Mk 84 2,000-pound bomb or BLU-109 hardened-target penetrator bomb. While the JDAM was initially expected to cost more than $40,000 apiece, the streamlined contracting methods pioneered on the program have knocked the unit cost to under $20,000 apiece. The Air Force plans to buy 62,000 JDAMs. The service plans to certify it on the F-16 this year and on the F-15E in 2002.

The standoff range required, the threat, the weather, and the hardness of the target all play a role in how weapons are chosen for a given mission, the Air Staff weapons expert said.

"Once you define those variables, it drives you to your weapon pretty quickly," he added.

JDAM was the star performer of Allied Force and vindicated USAF's move to GPS–aided weapons. Seen here in a test against an A-6 carcass, JDAM is classed as a near-precision weapon but routinely hits within 40 feet of its target.

While Desert Storm was largely credited as being the first space war—the first conflict in which space assets played a key role not only in communications and reconnaissance but in data transfer, target updates, and even weapon guidance—all these things happened to a much greater degree in Allied Force, according to Gen. Richard B. Myers, who was head of US Space Command, Air Force Space Command, and North American Aerospace Defense Command in January when he spoke to reporters in Washington.

The operational use of space assets in Allied Force was "an order of magnitude improvement over Desert Storm," he said. The use of GPS–aided munitions was made far more routine, and great progress was made in moving targeting information directly to the cockpit.

"One of the things that we've been working on ... [is] how do we get real-time information to the cockpit," Myers said.

"We had some terminals that we strapped onto the B-52 and the B-1 that would get information through a satellite relay and other broadcasts where they had the current [intelligence] picture," Myers explained. This threat picture could be sent to the bombers through an onboard e-mail capability and used in conjunction with onboard digital maps and GPS systems to create a new attack plan en route to the target area.

"That proved to be very, very useful," Myers said. "Air Combat Command is evaluating whether or not they want to put that permanently into the B-52s, the B-1, and perhaps the B-2." He noted, "The technology is essentially at hand" to do the same for all strike aircraft, but whether it will happen will have to be weighed against other spending priorities.

Similar episodes of the retargeting of airplanes and munitions took place throughout Allied Force, in which data from Joint STARS aircraft, reconnaissance satellites, U-2 reconnaissance aircraft, or UAVs were forwarded to the NATO Combined Air Operations Center in Vicenza, Italy, which then redirected attack airplanes already en route to targets in Kosovo.

Miniature Munitions

The Air Force is leading an Analysis of Alternatives to look at the technologies now becoming available that could yield the next generation of PGMs, according to Lynda Rutledge, program manager for the Miniaturized Munitions Capability at the Air Armament Center, Eglin AFB, Fla.

"The AOA will determine our road map" for investing in and producing new PGMs that are anticipated to be smaller, lighter, and smarter than today's munitions but still produce equivalent destructive power, Rutledge said. The AOA will be completed in September of this year and will select a few promising concepts to be carried

into further development from among 26 now under consideration.

"We're looking at a very broad target set: ... fixed targets, mobile targets, relocatable targets," Rutledge said. Among the alternatives being considered, she said, are some weapons "that are only effective against fixed targets," which typically require high explosives and deep penetrating capabilities, "and some that are only effective against mobile types," which tend to be "softer" and can be disabled with smaller warheads or cluster munitions.

Rutledge added, the study is an attempt to focus "where the Air Force wants to go in the future. ... It doesn't necessarily mean we will find one single answer."

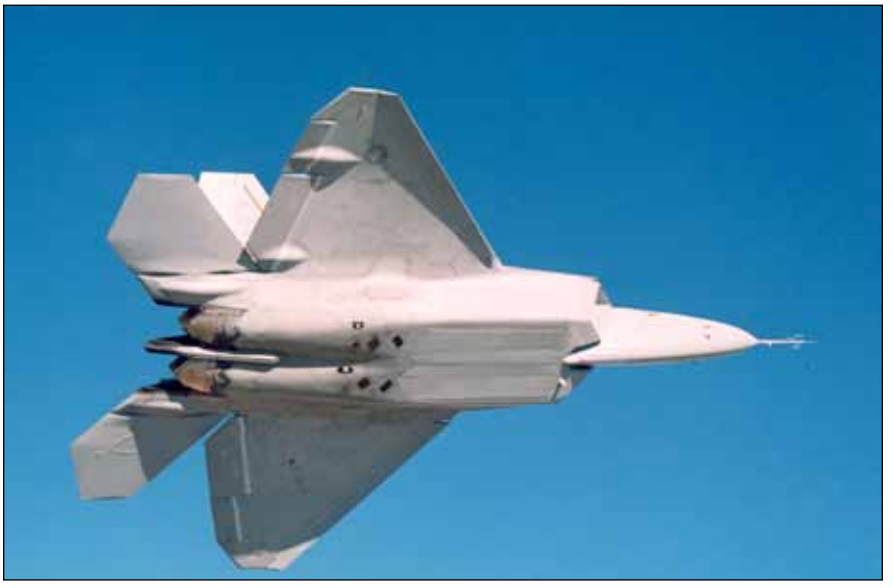


Photo by Paul Kennedy

The future of precision attack is smaller and smarter. The next generation of PGMs will have to fit in the weapon bays of stealthy aircraft like the F-22 (above right). Here, a LOCAAS warhead is tested at Eglin AFB, Fla. LOCAAS can find a target on its own, then configure itself to destroy what it finds.

The mission needs statement for new miniaturized munitions states that the Air Force wants such a capability for the F-22 in Fiscal 2007 and a capability for the Joint Strike Fighter in Fiscal 2010, noted Rutledge. The new weapons will have to be carried internally on the new aircraft, to preserve the fighters' stealthiness.

Two of the most prominent concepts include the Low Cost Autonomous Attack System and the Small Smart Bomb. The LOCAAS would be an arm's-length 100-pound gliding or powered weapon capable of orbiting the target area and searching for its target with a laser radar. Upon finding it, it would dive on it with a multistage warhead that would configure itself to be most effective against the target being attacked. The SSB would be similar to today's JDAM but would contain the explosive power of a 1,000- or 2,000-pound bomb in the body of a 250-pound bomb.

Preliminary laboratory work has shown that such high conventional yields can be obtained from smaller amounts of explosive materials, and the Air Force had hoped to fast track the SSB, but funding to develop and acquire the weapon was deferred until the five-year program beginning in Fiscal 2002, officials said.

The advantage of smaller, lighter weapons is that more individual munitions could be carried on each sortie, increasing the number of targets an aircraft could strike on each run. The resulting step-up in targets destroyed per sortie would offer an opportunity to accelerate an air campaign, while diminishing the cost to destroy each target.

"Increased loadout [weapons load] would provide a big increase in effectiveness," Rutledge noted. An F-22 now limited to two 1,000-pound JDAMs in its weapons bay—and thus limited to strike only one or two targets on a mission—could theoretically carry eight SSBs and destroy eight targets on one sortie. A B-2 that could attack 16 separate targets in Operation Allied Force with one 2,000-pound JDAM apiece might be able to attack more than 100 discrete targets with near-precision accuracy.

Another advantage of smaller weapons is that they can offer more options. Reduced blast means reduced collateral damage, and targets that might otherwise be off-limits because of their proximity to civilians or civilian structures could be safely hit without inflicting unwanted destruction.

It is possible the technology could be pointing to some sort of hybrid weapon for future fighters. However, said Rutledge, "We don't think it's going to happen, ... that we can accomplish the entire target set with one miniaturized munition. We will still need some large weapons for certain targets." ▪